Fatigue is the state of weariness that may result from prolonged physical or mental effort, anxiety and lack of adequate sleep or exposure to harsh environments. Fatigue is both a normal response in healthy people and a symptom of illnesses such as cancer, \(^1\) multiple sclerosis, \(^2-7\) chronic fatigue syndrome \(^8\) and fibromyalgia syndrome. \(^9,10\) Fatigue is broadly classified as acute/transient fatigue (e.g. after exercise), chronic fatigue (lasting unabated for more than six months) or chronic fatigue syndrome (chronic fatigue with co-morbidity).

It is well recognized within the literature that the level of human fatigue is correlated with performance indicators such as athletic results and injury, \(^11-17\) work productivity, performance and injury, \(^18-23\) decision making/cognitive performance, \(^24-28\) and mistakes and accidents. \(^29-35\) Therefore, it is important to understand the implications and consequences of fatigue within various settings and to minimize the impact of fatigue on catastrophic outcomes. The ability to quantify fatigue allows for the measurement of fatigue severity, and the subsequent identification of health and safety issues, and the need for treatment or testing the efficacy of any treatment for fatigue. There are many instruments available to measure fatigue, both psychometric instruments, such as the Fatigue Severity Scale, \(^36\) and objective tests, such as the hand grip strength dynamometer \(^37\) and Root Mean Square (RMS) value of electromyographic signals. \(^38,39\)

Fatigue may be conceptualized relative to different biopsychosocial aspects and fatigue research may focus on a specific aspect. For example, research into the involvement of the brain in fatigue would conceptualize fatigue relative to a pathophysiological model and attempt to understand biological mechanisms. \(^40\) In a contrasting example, the role of psychological stress in causing fatigue conceptualizes fatigue as a symptom or consequence of the stressor. \(^41,42\) Although different, the two conceptualizations of fatigue are not mutually exclusive or conflicting, but are instead connected. This current review will include research that focuses on any biopsychosocial aspect of fatigue using physiological, psychological or sociological models.

Physiological models may define fatigue as the loss of force generating capacity during muscular activity or relating to organ failure due to lack of physiological substrates. \(^43\) Central models of fatigue are those that are based on the involvement of the central nervous system’s contribution to fatigue. \(^43\) Imaging research suggests the significant involvement of the brain in...
fatigue. For example, Brodmann’s area 10/11 is associated with fatigue sensation and motivation.44 These models contrast with peripheral models that emphasize the metabolic exhaustion of the muscles or involve impaired motor-neuron end plate deficits, for example.43,45 Other models propose a model of complexity that includes control over fatigue processes which places the brain as a governor of exercise fatigue (Central Governor Theory).46,47

Psychological fatigue is different to mental fatigue in that mental fatigue relates to weariness that develops as a result of cognitive or mental work.38 Psychological fatigue is associated with stress and emotions and has been defined as a “...feeling of fatigue caused by things such as lack of exercise, boredom, or mental stress that results in lack of energy and depression.”49(para.1) It has been shown that depression may increase the risk of unexplained fatigue and the presence of unexplained fatigue may cause depression.50

Loriol places the study of fatigue into a sociological perspective: “...fatigue must be studied as a subjective feeling of tiredness related in complex and diverse manners to physical muscular effort, motivation processes and performances, and subject to socio-historical framing.”51(p.2),52 This point of view alludes to the influence of social settings and history on the meaning of fatigue. Therefore, it is important to consider any study of fatigue in the context of the social setting in which the study took place. The meaning of fatigue will be shaped by each unique social setting. For example, fatigue in aviators (setting = workplace/health and safety)33 has a different meaning and consequence than fatigue in children with cancer (setting = healthcare/family).54

This review seeks to scope the scientific literature related to the conceptual, theoretical and mechanistic knowledge of fatigue and identify instruments used to measure fatigue. This is intended to inform the future development of a theoretical model of fatigue and a systematic review of the measurement properties of instruments. To achieve these objectives, a scoping review of the literature is proposed.

The procedure and method for conducting a scoping review is published in the Joanna Briggs Institute Reviewer’s Manual55,56 upon which this scoping review will be founded. Essentially, scoping reviews are conducted to map specific knowledge domains. The purpose of a scoping review can include (one or all): the mapping of key concepts within a knowledge domain, clarifying definitions of terms, and defining the boundaries of the knowledge domain. Therefore, scoping reviews are useful in identifying key concepts and gaps in knowledge.

A search of PubMed and the JBI Database of Systematic Reviews and Implementation Reports using the search term “fatigue” revealed no current scoping reviews about fatigue, fatigue modelling or fatigue measurement. A systematic review published in 2009 considered fatigue measurement instruments,57 looking at validity of instruments assessing fatigue in chronic illnesses but it is not a scoping review, does not address the broader criteria of this current scoping review and is not current. A bibliographic study of fatigue measurement scales was conducted by Hjollund et al.58 and is also not current. Therefore, this current scoping review is timely.

Inclusion criteria

Participants
Articles that include humans may be included in this current review. Participants can be from any population, age, gender and with any health status.

Concept
The concept of interest is the definition of fatigue, the theoretical, conceptual and mechanistic models upon which fatigue is understood, and the measurement of fatigue. This current review will consider any of the different classifications of human fatigue, but not fatigue related to materials (“...[material] damage accumulate[ed] due to the repetitive application of loads...”),59(p.1) auditory fatigue (temporary loss of hearing sensitivity resulting from exposure to a loud tone)60 or fatigue related to other disciplines such as engineering and physics etc.

Context
Articles will be considered for inclusion in this review within the context of biological/physiological mechanisms, psychological expression or causes or the effect of fatigue on human function in social settings, such as the workplace or sports arena. Articles examining fatigue in states of health or illness may be included.

Types of studies
Systematic reviews, any quantitative or qualitative research studies, and expert opinion articles will be considered.
Methods

Search strategy
The search strategy will aim to find published and unpublished articles using a three-phase strategy. The first phase was a limited search of PubMed and Web of Science followed by analysis of the text words contained in the title and abstract and of the index terms used to describe the articles. This informed the development of the search strategy which will be tailored for each information source (second phase).

The results of each search will be loaded into EndNote V X.8 (Clarivate Analytics, PA, USA).

A third-phase search will look at the references in the articles included into the review for further articles.

Articles with titles and abstracts published in English will be included. Articles published in any year may be included because the development of theories and models of fatigue has publication history as early as the late 1800s. The chronological history of fatigue research is useful to identify the evolving understanding from an earlier reductionist model towards a biopsychosocial-complexity model.

A full search algorithm for PubMed is detailed in Appendix I.

Information sources
The databases/sources to be searched include: PubMed, Scopus, Web of Science, Cochrane Library, Embase, PsycINFO, JBI Database of Systematic Reviews and Implementation Reports.

The search for unpublished articles will include: EThOS (Electronic Thesis Online Service), ProQuest Dissertations and Theses: Global.

Study selection
Titles and abstracts or the full citation record will be screened for assessment against the inclusion criteria for the review. Articles that meet the inclusion criteria will be classified and retained in the Endnote library database. Studies that do not meet the inclusion criteria will be excluded and reasons for exclusion will be provided in an appendix in the final review report. Results of the search will be reported in full in the final report and presented in a PRISMA flow diagram.

Data extraction
Data about definitions of fatigue and theoretical models will be extracted from the first search results through evaluation of titles and abstracts and full text articles. This includes text defining fatigue, information describing the development of fatigue theories including history, pivotal commentaries, and mechanisms central to fatigue physiology. Data about measurement instruments and test methods will be extracted from the second search results through assessment of the contents of titles and abstracts or the full citation record. An Excel spreadsheet will be used to collect information, including: the name of the measurement instrument or test method; the number of articles mentioning each instrument or test method; the range of years of publications relative to each measurement instrument or test method; diagnostic categories based on World Health Organization Classification of Diseases (ICD-11) for which a specific psychometric instrument was applied; the settings in which the instrument or test method has been used; and the definition of specific test methods.

Data presentation
Data will be presented using, but not limited to: tables, figures, citation maps, word clouds, concept network maps and glossaries. In addition to this presentation, a discussion of the data and the significance of the findings will be given.

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References
Appendix I: Search strategy for PubMed

Search 1:

Search 2: